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Lithographic Apparatus

The present invention relates to a lithographic projection apparatus comprising:

5   -   a radiation system for supplying a projection beam of radiation;
       -        patterning means, for patterning the projection beam according to a desired pattern;
       -        a substrate table for holding a substrate; and
       -        a projection system for imaging the patterned beam onto a target portion on a first side of the substrate.

10

The term "patterning means" should be broadly interpreted as referring to means that can be used to endow an incoming radiation beam with a patterned cross-section, corresponding to a pattern that is to be created in a target portion of the substrate; 15 the term "light valve" has also been used in this context. Generally, the said pattern will correspond to a particular functional layer in a device being created in the target portion, such as an integrated circuit or other device (see below). Examples of such patterning means include:

       _   A mask table for holding a mask. The concept of a mask is well known in
20   lithography, and its includes mask types such as binary, alternating phase-shift, and attenuated phase-shift, as well as various hybrid mask types. Placement of such a mask in the radiation beam causes selective transmission (in the case of a transmissive mask) or reflection (in the case of a reflective mask) of the radiation impinging on the mask, according to the pattern on the mask. The mask table
25   ensures that the mask can be held at a desired position in the incoming radiation beam, and that it can be moved relative to the beam if so desired.
       _   A programmable mirror array. An example of such a device is a matrix-addressable surface having a viscoelastic control layer and a reflective surface. The basic principle behind such an apparatus is that (for example) addressed areas of the
30   reflective surface reflect incident light as diffracted light, whereas unaddressed areas reflect incident light as undiffracted light. Using an appropriate filter, the said undiffracted light can be filtered out of the reflected beam, leaving only the diffracted light behind; in this manner, the beam becomes patterned according to the addressing pattern of the matrix-adressable surface. The required matrix
35   addressing can be performed using suitable electronic means. More information on such mirror arrays can be gleaned, for example, from United States Patents US 5,296,891 and US 5,523,193, which are incorporated herein by reference.
       _   A programmable LCD array. An example of such a construction is given in United States Patent US 5,229,872, which is incorporated herein by reference.

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For purposes of simplicity, the rest of this text may, at certain locations, specifically direct itself to examples involving a mask table and mask; however, the general principles discussed in such instances should be seen in the broader context of the patterning means as hereabove set forth.

5   For the sake of simplicity, the projection system may hereinafter be referred to as the "lens"; however, this term should be broadly interpreted as encompassing various types of projection system, including refractive optics, reflective optics, and catadioptric systems, for example. The radiation system may also include components operating according to any of these design types for directing, shaping or controlling the projection

10   beam of radiation, and such components may also be referred to below, collectively or singularly, as a "lens". Further, the lithographic apparatus may be of a type having two or more substrate tables (and/or two or more mask tables). In such "multiple stage" devices the additional tables may be used in parallel, or preparatory steps may be carried out on one or more tables while one or more other tables are being used for exposures. Twin

15   stage lithographic apparatus are described, for example, in US 5,969,441 and US Serial No. 09/180,011, filed 27 February, 1998 (WO 98/40791), incorporated herein by reference.

Lithographic projection apparatus can be used, for example, in the manufacture of integrated circuits (ICs). In such a case, the patterning means may generate a circuit pattern corresponding to an individual layer of the IC, and this pattern can be

20   imaged onto a target portion (comprising one or more dies) on a substrate (silicon wafer) that has been coated with a layer of photosensitive material (resist). In general, a single wafer will contain a whole network of adjacent target portions that are successively irradiated via the projection system, one at a time. In current apparatus, employing patterning by a mask on a mask table, a distinction can be made between two different

25   types of machine. In one type of lithographic projection apparatus, each target portion is irradiated by exposing the entire mask pattern onto the target portion in one go; such an apparatus is commonly referred to as a wafer stepper. In an alternative apparatus — commonly referred to as a step-and-scan apparatus — each target portion is irradiated by progressively scanning the mask pattern under the projection beam in a given reference

30   direction (the "scanning" direction) while synchronously scanning the substrate table parallel or anti-parallel to this direction; since, in general, the projection system will have a magnification factor M (generally < 1), the speed V at which the substrate table is scanned will be a factor M times that at which the mask table is scanned. More information with regard to lithographic devices as here described can be gleaned, for example, from US

35   6,046,792, incorporated herein by reference.

Alignment is the process of positioning the image of a specific point on the mask to a specific point on the wafer which is to be exposed. Typically one or more alignment marks, such as a small pattern, are provided on each of the substrate and the mask. A device may consist of many layers which are built up by successive exposures with

intermediate processing steps. Before each exposure, alignment is performed to minimise any positional error between the new exposure and the previous ones, which error is termed overlay error.

5   However, some of the intermediate processing steps, such as chemical mechanical polishing (CMP), rapid thermal annealing, thick layer deposition and deep trench etching can damage or distort the alignment marks on the substrate. This can cause overlay errors.

    In some technologies, such as micro systems technology (MST) and micro electro mechanical systems (MEMS), devices are fabricated from both sides of a substrate. There has been a problem with performing exposures on one side of a substrate such that they are

10 accurately aligned with features previously exposed on the other side of the substrate. An alignment accuracy of the order of 0.5 microns or better is typically required.

15

    It is an object of the present invention is to alleviate, at least partially the above problems.

    This and other objects are achieved according to the invention in a lithography apparatus as specified in the opening paragraph, characterized by further comprising:

20   an alignment system for aligning a pattern of the patterning means with an alignment mark provided on the substrate; and

    an optical system for providing an image of said alignment mark for use by the alignment system, whereby the alignment mark is on the opposite side of the substrate to said first side.

25   Preferably, the image of the alignment mark is provided at the plane of the first side of the substrate. This enables a common alignment system to be used for alignment of marks on both sides of the substrate. Preferably the alignment system is capable of performing an alignment between features on the front and back of a substrate such that the accuracy of an exposure on one side with respect to features on the other side

30 is of the order of 0.5 microns or better.

    According to a further aspect of the invention there is provided a device manufacturing method comprising the steps of:

  – providing a substrate that is at least partially covered by a layer of radiation-sensitive material;

35 – providing a projection beam of radiation using a radiation system;

  – using patterning means to endow the projection beam with a pattern in its cross-section;

  – projecting the patterned beam of radiation onto a target area of the layer of radiation-sensitive material on a first side of said substrate,

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characterized by the steps of:

using an alignment system to align a pattern of the patterning means with an alignment mark provided on the substrate;

using an optical system to form an image of said alignment mark for use by the
5   alignment system, wherein the alignment mark is on the opposite side of the substrate to said first side; and

aligning said image of said alignment mark with said pattern of said patterning means.

10   In a manufacturing process using a lithographic projection apparatus according to the invention a pattern (e.g. in a mask) is imaged onto a substrate that is at least partially covered by a layer of energy-sensitive material (resist). Prior to this imaging step, the substrate may undergo various procedures, such as priming, resist coating and a soft bake. After exposure, the substrate may be subjected to other procedures, such as a
15   post-exposure bake (PEB), development, a hard bake and measurement/inspection of the imaged features. This array of procedures is used as a basis to pattern an individual layer of a device, e.g. an IC. Such a patterned layer may then undergo various processes such as etching, ion-implantation (doping), metallisation, oxidation, chemo-mechanical polishing, etc., all intended to finish off an individual layer. If several layers are required, then the
20   whole procedure, or a variant thereof, will have to be repeated for each new layer. Eventually, an array of devices will be present on the substrate (wafer). These devices are then separated from one another by a technique such as dicing or sawing, whence the individual devices can be mounted on a carrier, connected to pins, etc. Further information regarding such processes can be obtained, for example, from the book "Microchip
25   Fabrication: A Practical Guide to Semiconductor Processing", Third Edition, by Peter van Zant, McGraw Hill Publishing Co., 1997, ISBN 0-07-067250-4, incorporated herein by reference.

Although specific reference may be made in this text to the use of the apparatus according to the invention in the manufacture of ICs, it should be explicitly
30   understood that such an apparatus has many other possible applications. For example, it may be employed in the manufacture of integrated optical systems, guidance and detection patterns for magnetic domain memories, liquid-crystal display panels, thin-film magnetic heads, etc. The skilled artisan will appreciate that, in the context of such alternative applications, any use of the terms "wafer" or "die" in this text should be considered as
35   being replaced by the more general terms "substrate" and "target area", respectively.

In the present document, the terms illumination radiation and illumination beam are used to encompass all types of electromagnetic radiation, including ultraviolet radiation (e.g. with a wavelength of 365, 248, 193, 157 or 126 nm) and EUV, as well as particle beams, such as ion beams or electron beams.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings in which:

Figure 1 depicts a lithographic projection apparatus according to an embodiment of the invention;

Figure 2 is a schematic cross section illustrating the substrate table incorporating two branches of an optical system for double side alignment according to an embodiment of the invention;

Figure 3 is a plan view of a wafer showing the position and orientation of the double side alignment optics according to an embodiment of the invention;

Figure 4 is plan view showing an alternative position and orientation of the double side alignment optics according to the invention;

Figure 5 is a cross section of a portion of a substrate table having integral optical components according to an embodiment of the invention;

Figure 6 is a schematic cross section of a substrate table showing the optical system for double side alignment according to a further embodiment of the invention; and

Figures 7 and 8 illustrate schematically the alignment optics for the alignment for two wafer marks with two mask marks.

In the Figures, corresponding reference symbols indicate corresponding parts.

Embodiment 1

Figure 1 schematically depicts a lithographic projection apparatus according to a particular embodiment of the invention. The apparatus comprises:

- a radiation system LA, Ex, IL, for supplying a projection beam PB of radiation (*e.g.* UV radiation);

- a first object table (mask table) MT for holding a mask MA (*e.g.* a reticle), and connected to first positioning means for accurately positioning the mask with respect to item PL;

- a second object table (substrate table) WT for holding a substrate W (*e.g.* a resist-coated silicon wafer), and connected to second positioning means for accurately positioning the substrate with respect to item PL;

- a projection system ("lens") PL (*e.g.* a quartz lens system) for imaging an irradiated portion of the mask MA onto a target portion C (comprising one or more dies) of

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the substrate W.

As here depicted, the apparatus is of a transmissive type (*i.e.* has a transmissive mask). However, in general, it may also be of a reflective type, for example (with a reflective mask). Alternatively, the apparatus may employ another kind of patterning means, such as

5   a programmable mirror array of a type as referred to above.

The radiation system comprises a source LA (*e.g.* a UV laser) that produces a beam of radiation. This beam is fed into an illumination system (illuminator) IL, either directly or after being passed through conditioning means, such as a beam expander Ex, for example. The illuminator IL comprises adjusting means AM for setting the outer and/or

10   inner radial extent (commonly referred to as σ-outer and σ-inner, respectively) of the intensity distribution in the beam. In addition, it will generally comprise various other components, such as an integrator IN and a condenser CO. In this way, the beam PB impinging on the mask MA has a desired uniformity and intensity distribution in its cross-section.

15   It should be noted with regard to Figure 1 that the source LA may be within the housing of the lithographic projection apparatus (as is often the case when the source LA is a mercury lamp, for example), but that it may also be remote from the lithographic projection apparatus, the radiation beam which it produces being led into the apparatus (e.g. with the aid of suitable directing mirrors); this latter scenario is often the case when

20   the source LA is an excimer laser. The current invention and Claims encompass both of these scenarios.

The beam PB subsequently intercepts the mask MA which is held in a mask holder on a mask table MT. Having traversed the mask MA, the beam PB passes through the lens PL, which focuses the beam PB onto a target portion C of the substrate W. With

25   the aid of the second positioning means (and interferometric measuring means IF), the substrate table WT can be moved accurately, *e.g.* so as to position different target portions C in the path of the beam PB. Similarly, the first positioning means can be used to accurately position the mask MA with respect to the path of the beam PB, *e.g.* after mechanical retrieval of the mask MA from a mask library, or during a scan. In general,

30   movement of the object tables MT, WT will be realized with the aid of a long stroke module (course positioning) and a short stroke module (fine positioning), which are not explicitly depicted in Figure 1. However, in the case of a wafer stepper (as opposed to a step-and-scan apparatus) the mask table MT may just be connected to a short stroke actuator, or may be fixed.

35   The depicted apparatus can be used in two different modes:

1.   In step mode, the mask table MT is kept essentially stationary, and an entire mask image is projected in one go (*i.e.* a single "flash") onto a target portion C. The substrate table WT is then shifted in the x and/or y directions so that a different target portion C can be irradiated by the beam PB;

2. In scan mode, essentially the same scenario applies, except that a given target portion C is not exposed in a single "flash". Instead, the mask table MT is movable in a given direction (the so-called "scan direction", *e.g.* the x direction) with a speed *v*, so that the projection beam PB is caused to scan over a mask image; concurrently, the substrate table WT is simultaneously moved in the same or opposite direction at a speed *V* = *Mv*, in which *M* is the magnification of the lens PL (typically, *M* = 1/4 or 1/5). In this manner, a relatively large target portion C can be exposed, without having to compromise on resolution.

Figure 2 shows a wafer W on a wafer table WT. Wafer marks WM3 and WM4 are provided on a first side ("front side") of the wafer W and light can be reflected from these marks, as indicated by the arrows above WM3 and WM4, and used for alignment with marks on a mask in conjunction with an alignment system (not shown) which will be described later. Further wafer marks WM1 and WM2 are provided on the second side ("back side") of the wafer W. An optical system is built into the wafer table WT for providing optical access to the wafer marks WM1, WM2 on the back side of the wafer W. The optical system comprises a pair of arms 10A, 10B. Each arm consists of two mirrors, 12, 14 and two lenses 16, 18. The mirrors 12, 14 in each arm are inclined such that the sum of the angles that they make with the horizontal is 90°. In this way, a beam of light impinging vertically on one of the mirrors will remain vertical when reflected off the other mirror.

In use, light is directed from above the wafer table WT onto mirror 12, through lenses 16 and 18, onto mirror 14 and then onto the respective wafer mark WM1, WM2. Light is reflected off portions of the wafer mark and returns along the arm of the optical system via mirror 14, lenses 18 and 16 and mirror 12. The mirrors 12, 14 and lenses 16, 18 are arranged such that an image 20A, 20B of the wafer mark WM1, WM2 is formed at the plane of the front (top) surface of the wafer W, corresponding to the vertical position of any wafer marks WM3, WM4 provided on the front side of the wafer W.

An image 20A, 20B of a wafer mark WM1, WM2 acts as a virtual wafer mark and can be used for alignment by the pre-existing alignment system (not shown) in exactly the same way as a real wafer mark provided on the front (top) side of the wafer W.

As shown in Figure 2, the arms of the optical system 10A, 10B produce images 20A, 20B which are displaced to the side of the wafer W so that they can be viewed by an alignment system above the wafer W. Two preferred orientations of the arms of the optical system 10A, 10B are shown in Figures 3 and 4, which are plan views of the wafer W, which lies in the XY plane. The wafer table WT is omitted from Figures 3 and 4 for clarity. In Figure 3, the arms of the optical system 10A, 10B are aligned along the X axis. In Figure 4, the arms of the optical system 10A, 10B are parallel to the Y axis. In both cases, the wafer marks WM1, WM2 lie on the X axis. The wafer marks WM1, WM2 are on the underside of the wafer W, so are reversed from the point of view of the top side of

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the wafer W. However, the arrangement of the mirrors of the arms of the optical system mean that the images 20A, 20B of the wafer marks WM1, WM2 are restored to be the correct way round again, not inverted, so that the images appear exactly the same as if they were on the top side of the wafer W. The optical system is also arranged so that the ratio

5   of the size of a wafer mark WM1, WM2 to its image 20A, 20B is 1:1 i.e. there is no magnification or reduction. Consequently, the images 20A, 20B can be used exactly as if they were real wafer marks on the front side of the wafer W. A common alignment pattern or key provided on a mask can be used to perform alignment with both real and virtual wafer marks.

10   In the current example, wafer marks are provided on both the front and back sides of the wafer W at corresponding positions, as shown in Figure 2. In Figures 3 and 4, only the wafer marks on the back side of the wafer W are shown, for clarity. According to this arrangement, when the wafer W is flipped over, by rotation about either of the X or Y axes, a wafer mark which was on the top side of the wafer W is now on the underside, but

15   at a position such that it can be imaged by an arm of the optical system 10A, 10B.

It will be noted that, because of the mirror arrangement, displacement of the wafer in one direction parallel to an arm 10A, 10B of the optical system will displace the corresponding image 20A, 20B of a wafer mark WM1, WM2 on the under side of the wafer in the opposite direction. For example, in Figure 3, if the wafer W were displaced to

20   the right, the images 20A, 20B would be displaced to the left. Software controlling the alignment system takes this into account when determining the position of the wafer marks WM1, WM2 and when adjusting the relative positions of the wafer W and a mask when performing alignment. If the two arms of the optical system 10A, 10B are symmetric then the separation between the images 20A and 20B will in fact stay constant when the wafer

25   is displaced.

At least two wafer marks are provided per side of the wafer W. A single mark can give information about the relative positioning of an image of a specific point on a mask to a specific point on the wafer. However, to ensure the correct orientational alignment and magnification, at least two marks are used.

30   Figure 5 shows a portion of the wafer table WT in cross section. According to this embodiment of the invention, the optical system 10A, 10B for imaging the wafer marks on the back side of a wafer is built into the wafer table in a particular fashion. As shown in Figure 5, the mirrors 12, 14 of an arm of the optical system are not provided as discrete components, but are integral with the wafer table WT. Appropriate faces are

35   machined into the wafer table WT, which may then be provided with a coating to improve reflectivity, thus forming the mirrors 12, 14. The optical system is made from the same material as the wafer table, such a Zerodur, which has a very low coefficient of thermal expansion and therefore ensures that high alignment accuracy can be maintained.

alignment system is capable of performing alignment using an alignment mark provided on the first side of the substrate as well as using said alignment mark image provided by said optical system.

5 　9. 　　　　An apparatus according to any one of the preceding claims, further comprising a reverser for turning over the substrate such that said first side and said opposite side are swapped.

10. 　　　　An apparatus according to any one of the preceding claims, further
10 　comprising means for deriving a relationship between alignment marks on both sides of the substrate.

11. 　　　　An apparatus according to any one of the preceding claims, wherein the patterning means comprise a mask table for holding a mask.
15

12. 　　　　An apparatus according to claim 11, wherein said pattern of said patterning means used for alignment is an alignment mark provided on said mask.

13. 　　　　A device manufacturing method comprising the steps of:
20 　_ 　　　providing a substrate that is at least partially covered by a layer of radiation-sensitive material;
　　　_ 　　　providing a projection beam of radiation using a radiation system;
　　　_ 　　　using patterning means to endow the projection beam with a pattern in its cross-section;
25 　_ 　　　projecting the patterned beam of radiation onto a target area of the layer of radiation-sensitive material on a first side of said substrate,
　　　　　　　characterized by the steps of:
　　　　　　　using an alignment system to align a pattern of the patterning means with an alignment mark provided on the substrate;
30 　　　　　using an optical system to form an image of said alignment mark for use by the alignment system, wherein the alignment mark is on the opposite side of the substrate to said first side; and
　　　　　　　aligning said image of said alignment mark with said pattern of said patterning means.
35

14. 　　　　A method according to claim 13, further comprising the step of:
　　　　　　　forming the image of the alignment mark at the plane of said first side of the substrate.

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CLAIMS:

5   1.   A lithographic projection apparatus comprising:
     _   a radiation system for providing a projection beam of radiation;
     _   patterning means, for patterning the projection beam according to a desired pattern;
     _   a substrate table for holding a substrate;
     _   a projection system for imaging the patterned beam onto a target portion on a first
10   side of the substrate,
     characterized by further comprising:
                 an alignment system for aligning a pattern of the patterning means with an
     alignment mark provided on the substrate; and
                 an optical system for providing an image of said alignment mark for use by the
15   alignment system, whereby the alignment mark is on the opposite side of the substrate to
     said first side.

     2.   An apparatus according to claim 1, wherein said optical system is arranged
     to provide an image of said alignment mark at the plane of the first side of the substrate.
20
     3.   An apparatus according to claim 1 or 2, wherein said optical system
     comprises means for providing a plurality of images, each corresponding to a respective
     one of a plurality of alignment marks.

25   4.   An apparatus according to claim 1, 2 or 3, wherein said optical system
     comprises at least two mirrors and lenses.

     5.   An apparatus according to any one of the preceding claims, wherein said
     optical system comprises at least one optical fibre.
30
     6.   An apparatus according to any one of the preceding claims, wherein said.
     optical system is integral with said substrate table.

     7.   An apparatus according to any one of the preceding claims, wherein the
35   optical system is arranged to provide the or each alignment mark image displaced laterally
     from the corresponding alignment mark along one of the principal axes of the apparatus
     and beyond the periphery of the area to be occupied by the substrate.

     8.   An apparatus according to any one of the preceding claims, wherein said

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and orientation of features on the first side (now the underside) of the wafer relative to the
mask is established. Second wafer marks can then be exposed on the second side of the
wafer (now on top) (or the second wafer marks could already have been provided). The
relative position and orientation of the second wafer marks with respect to the first wafer
5   marks can be determined through the mask marks and the alignment system. Exposures of
features can then be done on the second side of the wafer, using the second wafer marks,
and any necessary correction to ensure that they are accurately aligned with the features on
the first side of the wafer. Once the relative relationship between the wafer marks on the
first and second sides of the wafer is known, exposures can be performed on either side
10   using either or both sets of marks whilst ensuring accurate alignment with features on the
opposite side of the wafer.

If device features are to be formed on only one side of the wafer, the same
apparatus can be used, but using only wafer marks on the back side of the wafer for
alignment. The masks for all exposures on the front side can be aligned using the images
15   of the back side wafer marks. It is not necessary to know the absolute relationship between
the wafer marks on the back side and the features exposed on the front side, provided all
masks for exposure on the front side are consistently aligned using the images of the back
side wafer marks. The wafer marks on the back side will not become deteriorated because
the processing is done on the front side of the wafer.

20

Whilst specific embodiments of the invention have been described above, it
will be appreciated that the invention may be practiced otherwise than as described. The
description is not intended to limit the invention.

Embodiment 2

Figure 6 is a view corresponding to that of Figure 2, but with the arms 10A, 10B of the optical system embodied using respective optical fibres 30 (or coherent optical fibre bundles) and lenses 32, 34 to couple light into and out of the fibres 30. The fibres and lenses are used to provide an image 20A, 20B of a wafer mark WM1, WM2 on the back side of the wafer W. The images 20A, 20B are located in the same plane as the wafer marks WM3, WM4 on the front side of the wafer W.

Figures 7 and 8 illustrate further aspects of the alignment system. In Figure 7, a source of radiation, such as a laser 40, e.g. a HeNe laser, directs a beam of alignment light onto a first beam splitter BS1, whereby a portion of the light is directed down through the arm 10A of the optical system in the wafer table WT, and is reflected off a first wafer mark WM1 on the back side of the wafer W, to form an image 20A of the alignment mark. Light from this image 20A passes back through the first beam splitter BS1, through a lens system PL and then through a first mask mark MM1 provided on a mask MA and onto a first detector D1. The signal produced by the detector D1 can be used to determine correct registration between the first mask mark MM1 and the image 20A. The relationship between the image 20A and the wafer mark WM1 is known from the optics 10A, and so alignment between the first mask mark MM1 and the first wafer mark WM1 can be determined. The wafer W and/or mask MA can be moved relative to one another to achieve alignment.

The alignment system of this example is a through-the-lens (TTL) arrangement, such that the lens system PL between the mask MA and the wafer W is actually the projection lens used for the exposure radiation. However, the alignment system can also be off-axis (OA).

In Figure 8, a second wafer mark WM2 is aligned with a second mask mark MM2, using a second beam splitter BS2 and the other arm 10B of the optical system. The process can be repeated to align, for example, the first mask mark MM1 with the second wafer mark WM2 and so on. Alignments can also be performed with wafer marks provided on the front (top) side of the wafer and the same or further mask marks.

An example of a double side alignment method is as follows. First wafer marks are provided on a first side of a wafer. One or more exposures are performed on that side using the first wafer marks for alignment in the usual way. Thus the position of features on the first side of the wafer relative to those first wafer marks is well established. The wafer is turned over so that the first side is now facing down and so that exposures can be performed on the second side. Using the optical system in the wafer table, the first wafer marks are imaged and are aligned relative to marks on a mask, so that the position

15.   A method according to claim 13 or 14, further comprising the step of:

aligning an alignment mark provided on the first side of the substrate with a pattern of said patterning means.

5   16.   A method according to claim 13, 14 or 15, further comprising the steps of:

turning over the substrate so that said first side and said opposite side are swapped; and

repeating the alignment.

10   17.   A method according to any one of claims 13 to 16, further comprising the step of:

deriving a relationship between alignment marks on both sides of the substrate.

15   18.   A device manufactured according to the method of any one of claims 13 to 17.

19.   A device according to claim 18, which is one of an integrated circuit and a micro-electromechanical system.

20

ABSTRACT

Lithographic Apparatus

5

A lithographic projection apparatus is provided with an optical system built into the wafer table for producing an image of a wafer mark which is provided on the back side of the wafer. The image is located at the plane of the front side of the wafer and can be viewed by an alignment system from the front side of the wafer. Simultaneous alignment

10 between marks on the back and front of the wafer and a mask can be performed using a pre-existing alignment system
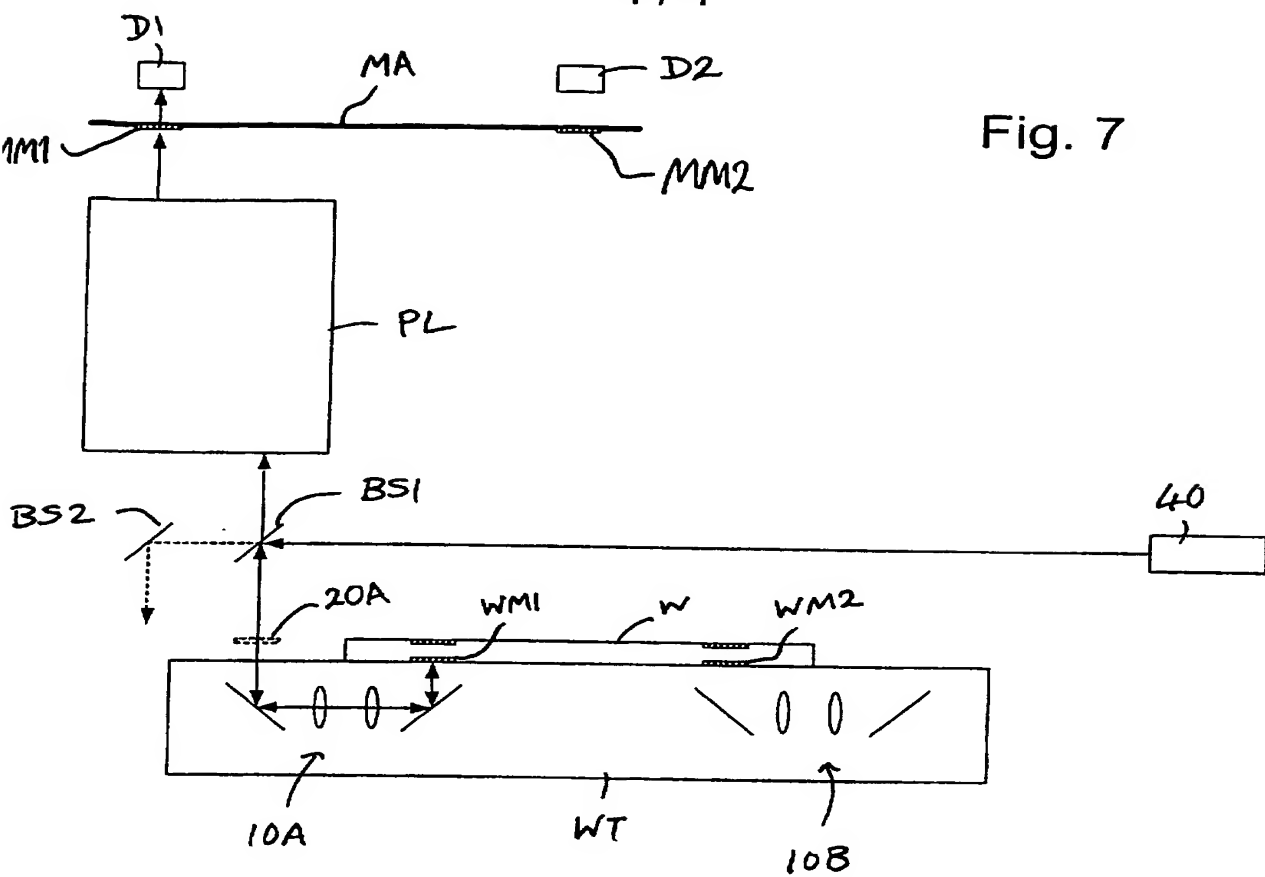
Fig. 2

Fig. 1

Fig. 2

Fig. 3

Fig. 4

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Fig. 7

Fig. 8

Fig. 5

Fig. 6